Logistics
Report

For the

High Resolution Fixed-Wing Magnetic
Airborne Geophysical Survey

Flown over

Sustina (A1) and Add-On Blocks

From

Skwentna Roadhouse, Alaska, USA

Carried out on behalf of

U.S. GEOLOGICAL SURVEY

By

New-Sense Geophysics Limited

Toronto, Canada
January 16th, 2013
(NSG Project ID: FMI120918-report
USGS Contract No: G12PC00060)

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AMENDMENT RECORD

Rev	Date	Description	Report Section	Prepared by

DOCUMENT RECORD

Document Identification	FMI120918-report
Document Custodian	Field Operations Manager
Relates To	Final Deliverables
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1. INTRODUCTION

A high sensitivity fixed-wing magnetic airborne survey was carried out for U.S. Geological Survey (Client) from Skwentna Roadhouse, AK, USA, over the survey blocks known as: Sustina (A1), and Add-On (see Tables 2.1-2.2 and Figure 2.1).

New-Sense Geophysics Ltd. (NSG) flew the survey under the terms of an agreement with Client dated September 7th, 2012.

The survey was flown between October 11th and November 1st, 2012. A total of 10,827* line kilometers of field magnetic data were flown, collected, processed and plotted.

*
Sustina (A1) Block: 7,700 km
Add-On Block: 3,127 km

The primary geophysical sensor was a high-sensitivity Cesium-3 magnetometer, mounted in a fixed tail stinger assembly. Airborne ancillary equipment included; iCAM (digital video recorder), iDAS data acquisition system, fluxgate magnetometer, radar altimeter, and global positioning system (GPS) receiver. The GPS system provided accurate real-time navigation and subsequent flight path recovery. Ground equipment included; high-sensitivity Cesium-3 magnetometer, iBASE data acquisition system, global positioning system (GPS) receiver, and PC-based field workstation. The GPS receiver was used for time synchronization with airborne data. The field computer was used to check the data quality and completeness on a daily basis.

The technical objective of the survey was to provide high-resolution total field magnetic maps suitable for anomaly delineation, detailed structural evaluation, and identification of lithologic trends. Fully corrected magnetic maps were prepared by New-Sense Geophysics Limited, in their Toronto office, after the completion of survey activities.

This report describes the acquisition, processing, and presentation of data for the Sustina (A1) and Add-On blocks, AK, USA.

2. SURVEY LOCATION

Datum: NAD27
Projection: UTM Zone 5N
Local Datum Transform: USA-Alaska mainland

Table 2.1: Sustina (A1) block coordinates

NAD27_X	NAD27_Y	WGS84_X	WGS84_Y	NAD27_LONGITUDE	NAD27_LATITUDE
UTM Zone 5N				USA-Alaska mainland	
599069	6859088	598950	6859226	-151.117470	61.853450
657826	6906486	657704	6906625	-149.960280	62.258520
655949	6942214	655828	6942353	-149.964080	62.579550
626567	6959026	626447	6959165	-150.522790	62.741540
604734	6920410	604613	6920549	-150.973480	62.402040
569676	6909571	569556	6909708	-151.655910	62.312980
544643	6909086	544525	6909223	-152.138840	62.312460
556716	6885231	556597	6885369	-151.913720	62.096740
598539	6857742	598420	6857882	-151.128280	61.841520

Table 2.2: Add-On block coordinates

NAD27_X	NAD27_Y	WGS84_X	WGS84_Y	NAD27_LONGITUDE	NAD27_LATITUDE
UTM Zone 5N				USA-Alaska mainland	
555951	6888188	555832	6888326	-151.927431	62.123393
527657	6860330	527538	6860467	-152.474118	61.876481
526095	6873132	525976	6873270	-152.501952	61.991507
478334	6873265	478216	6873399	-153.413543	61.992976
460286	6891355	460170	6891489	-153.762051	62.15388
444083	6927628	443968	6927763	-154.084577	62.477352
475721	6944575	475606	6944710	-153.473375	62.632876
505078	6914304	504961	6914440	-152.901883	62.361937
545346	6909064	545228	6909201	-152.125296	62.312178

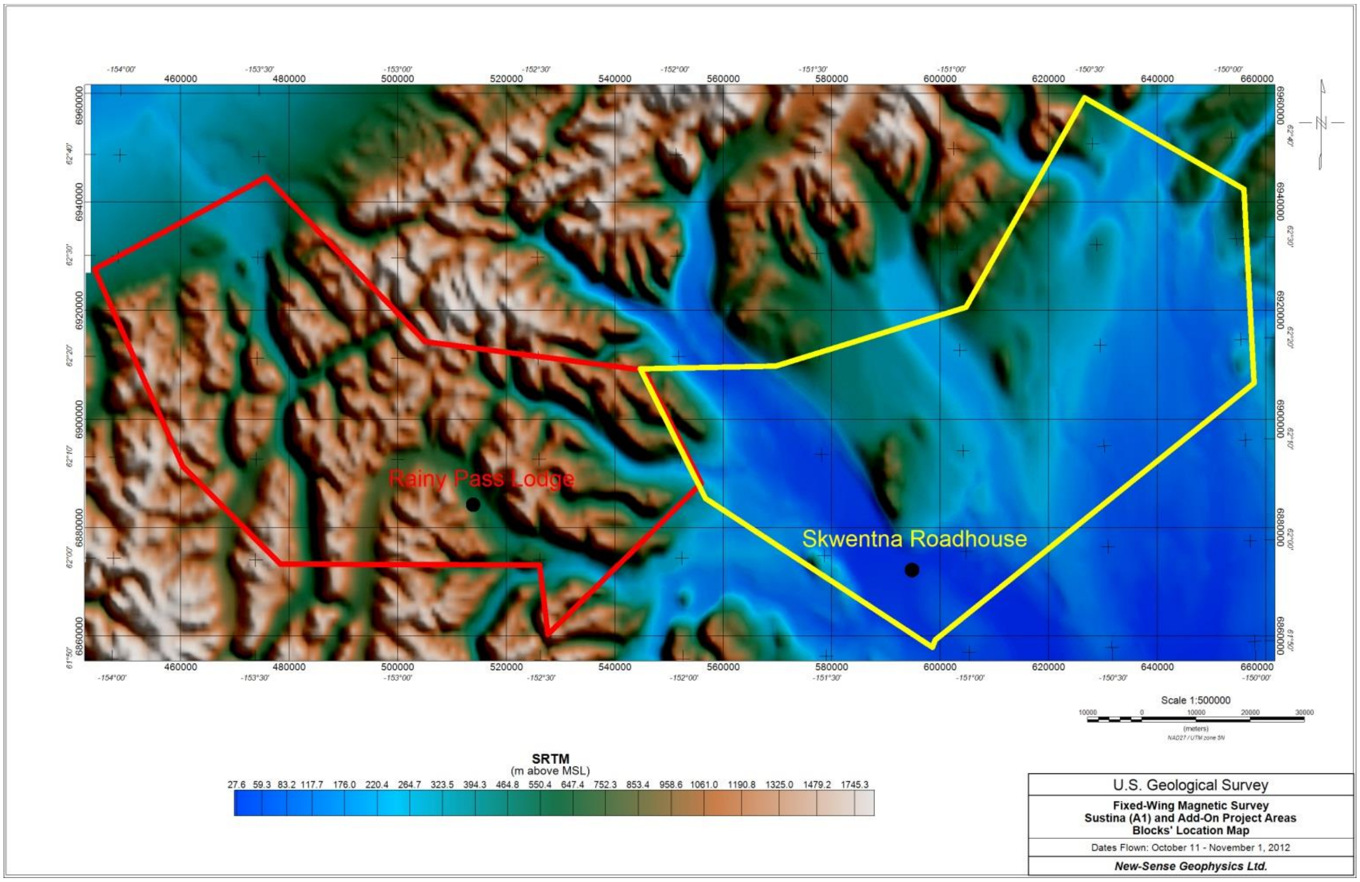


Figure 2.1 Location map depicting outlines of the flown Sustina (A1) (yellow) and Add-On (red) blocks. Coordinate System: NAD27, UTM Zone 5N, USA-Alaska mainland.

3. PERSONNEL

3.1 FIELD OPERATIONS

New-Sense Geophysics Ltd., Geophysicist:	Pawel Starmach
Brucelandair International, Pilot:	Marshall Burn

3.2 OFFICE DATA PROCESSING AND OFFSITE QA/QC

QA/QC (NSG):	Andrei Yakovenko
Data Processing and Grids (NSG):	Andrei Yakovenko Pawel Starmach
Logistics Report (NSG):	Andrei Yakovenko

3.3 PROJECT MANAGEMENT

New-Sense Geophysics Ltd.:	Andrei Yakovenko
U.S. Geological Survey:	Richard Saltus, Ph.D., Research Geophysicist

4. SURVEY PARAMETERS

Airborne Digital Record:	Line Number Line Direction Flight Number Julian Date Fiducial Operating System Time Instrument Clock GPS Time Radar Altimeter Total Field Magnetics Raw Global Positioning System (GPS) data Magnetic compensation parameters (fluxgate mag.)
iCAM:	Navigation File Name Line Number UTC Time Latitude Longitude GPS Height
Base Station Record:	Ambient Total Field Magnetics Raw Global Positioning System (GPS) data Time (System and GPS)

Table 4.1 Survey Parameters and Statistics

	Sustina (A1)	**Add-On Block**
Traverse Line spacing:	800m	1,600m
Control Line spacing:	8,000m	16,000m
Traverse Line direction:	135^0/315^0	
Control Line direction:	45^0/225^0	
Measurement interval:	0.02/0.1 sec	
Average Terrain clearance:	306m	
Measurement spacing (average):	7.5m	
Groundspeed (average):	270km/hr	

5. AIRCRAFT AND EQUIPMENT

5.1 AIRCRAFT

The aircraft used was a Piper Aztec (C-FBPA) equipped with a Cesium magnetometer mounted in a fixed tail stinger assembly. The aviation company providing the aircraft service was Brucelandair International Inc., based in Wiarton, ON, Canada.

5.2 AIRBORNE GEOPHYSICAL SYSTEM

5.2.1 MAGNETOMETER

One Scintrex CS-3 optically pumped Cesium split beam sensor was mounted in a fixed tail stinger assembly. The magnetometer's Larmor frequency output was processed by a KMAG-4 magnetometer counter, which provides a resolution of 0.15 ppm (in a magnetic field of 50,000 nT, resolution equivalent to 0.0075 nT). The raw magnetic data was recorded at 50 Hz, anti-aliased with 31 point COSINE filter, and resampled to 10 Hz .

5.2.2 MAGNETIC COMPENSATION

The proximity of the aircraft to the magnetic sensor creates a measurable anomalous response as a result of the aircrafts movement. The orientation of the aircraft with respect to the sensor and the motion of the aircraft through the earth's magnetic field are contributing factors to the strength of this response. A special calibration flight, Figure of Merit (i.e., FOM), was flown to record the information necessary to compensate for these effects.

The FOM maneuvers consist of a series of calibration lines flown at high altitude to gain information in each of the required line directions. During this procedure, pitch, roll and yaw maneuvers are performed on the aircraft (typical angle ranges are 15^o pitch, 15^o roll, and 15^o yaw). Each variation is conducted three times in succession (first pitch, then roll, then yaw), providing a complete picture of the aircraft's effects at designated headings in all orientations.

A three-axis Bartington fluxgate magnetometer (recorded at 50 Hz), was used to measure the orientation and rates of change of the magnetic field of the aircraft, away from localized terrestrial magnetic anomalies. An ENIGMA digital compensation algorithm was then applied to generate a correction factor to compensate for permanent, induced, and eddy current magnetic responses generated by the aircrafts movements.

5.2.3 GPS NAVIGATION

A NovAtel state of the art OEM628 GPS board was used for navigation and flight path recovery. The OEM628 is designed with NovAtel's new 120 channel ASIC, which tracks all current and upcoming GNSS constellations and satellite signals including GPS, GLONASS, and Compass.

The channels were configured for GPS: L1, L2, and DGPS.

5.2.4 ALTIMETER

A TRA 3500 radar altimeter was mounted on the fuselage of the aircraft. This instrument operates with a linear performance over the range of 0 to 2,500 feet and records the terrain clearance of the sensors. The raw radar altimeter data was recorded at 50 Hz, anti-aliased with a 21 point COSINE filter and re-sampled at 10 Hz.

5.2.5 GEOPHYSICAL FLIGHT CONTROL SYSTEM

New-Sense's iNAV V4 geophysical flight control system monitored and recorded magnetometer, altimeter, and GPS equipment performance. Input from the various sensors was monitored every 0.005 seconds for the precise coordination of geophysical and positional measurements. The input was recorded fifty times per second (one time per second in the case of GPS and radiometric data).

GPS positional coordinates and terrain clearance were presented to the pilot by means of a panel mounted indicator display. The magnetometer response, forth difference, altimeter profile and profiles of the radiometric windows were also available on the touch screen display, for real-time monitoring of equipment performance.

5.2.6 IDAS DIGITAL RECORDING

The output of the CS-3 magnetometer, fluxgate magnetometer, altimeter, GPS coordinates, and time (system and GPS), were recorded digitally on a solid state drive (SSD) at a sample rate of fifty times per second (ten times per second for GPS) by the NSG iNAV system.

5.3 ICAM VIDEO RECORDING SYSTEM

A Panasonic color CC TV Camera, model number WV-CP484, was mounted below the body of the aircraft and positioned directly facing the ground surface. The WV-CP484 camera features a 1/3 inch pick-up CCD tube with a 768×494 pixel array.

A Panasonic WV-LA210C3 2.1mm aspherical TV (fish eye) lens was used on the WV-CP484 camera. This super wide-angle lens features a 1:1.0 maximum aperture ratio and an angular field of view of $107.6^{\circ} H \times 88.0^{\circ} V$.

The video signal was captured, processed and recorded using the iCAM system, a digital flight path video camera system. Using iDAS and GPS system input the iCAM overlays current flight data onto the video frames and produces a MPEG4 encoding format AVI file. The video produced is in the standard NTSC 30 frames per second format, at 720x480 pixel resolution.

The overlaid text information is presented in two columns as shown below:

Left column (iDAS System Information)

1) Current navigation file name
2) Current line number

Right Column (GPS Information)

3) UTC clock
4) Latitude (WGS 84) – formatted ddmm.mmmmmN
5) Longitude (WGS 84) – formatted dddmm.mmmmmW
6) GPS height (meters above sea level) (WGS 84)
7) Number of satellites visible

All flight videos have been included on 34 DVD's (see Section 7). The DVD's have been labeled "Sustina Airborne iCAM Video Files:" On each DVD there includes a directory for each flight labeled "FLTXXX.X" (i.e.,: "FLT001 or FLT001.A, FLT001B etc " for flight 1). Included in each flight directory are the AVI flight videos, 1 for each line, a single ".cor" file and a single ".log" file.

The AVI file names are formatted as "Flight line"_"Flight number"_"file version (optional)".avi (ie: 1050_4 represents flight line 1050, flight 4). Multiple versions of files only created if duplicate on the system, only final copy recorded to DVD.

The COR file is a time correlation file that can be used by a software package, Video Link System (VLS), to display video segments that correspond to geophysical data being viewed in Geosoft Oasis Montaj.

The LOG file is used to record critical information in the operation of the iCAM. It can be used to diagnose issues with iCAM system if there are video quality concerns.

Both COR & LOG filenames are formatted in the following method, YYYYMMDDHHmmSS.cor & YYYYMMDDHHmmSS.log

YYYY	Year, Example: 2004
MM	Month (01-12), Example: February = "02"
DD	Day (01-31), Example: "05"
HH	Hour (00-23), Example: noon = "12"
mm	Minute (00-59), Example: 8 minutes = "08"
SS	Seconds (00-59), Example: 7 seconds = "07"

5.4 GROUND MONITORING SYSTEM

5.4.1 BASE STATION MAGNETOMETER

A Scintrex CS-3 optically pumped cesium split beam sensor was used at the base of operations within the camp site boundaries, in an area of low magnetic gradient as well as low cultural electric and magnetic noise sources. The sensitivity and absolute accuracy of the ground magnetometer is +/- 0.01 nT. Data were recorded continuously at fifty times per second throughout all survey operations in digital form to a solid state hard drive (SSD). Both the ground and airborne magnetic readings were synchronized based on the GPS UTC clock.

5.4.2 RECORDING

The output of the magnetic and GPS monitors was recorded digitally on a solid state hard drive (SSD). A visual record of the last three hours was graphically maintained on the computer screen to provide an up-to-date appraisal of magnetic activity. At the conclusion of each production flight, raw GPS and magnetic data were transferred to the main field compilation computer.

5.5 FIELD COMPILATION SYSTEM

A field laptop computer was used for field data processing and presentation. The raw data was imported to Geosoft Oasis montaj for QA/QC and processing purposes. After the data was checked for quality control, the the uncompensated magnetic readings were magnetically compensated with a QC Tools software package GX, and base station data was merged to have a complete single flight database. The complete database was then for final field review and it and the raw data were transmitted to the office.

6. OPERATIONS AND PROCEDURES

6.1 FLIGHT PLANNING AND FLIGHT PATH

The block outline coordinates (section 2.0) were used to generate pre-calculated navigation files. The navigation files were used to plan flights at the designated traverse line spacing of 800 meters and control lines of 8,000 meters for Sustina (A1) block; and 1,600 meters and control lines of 16,000 meters for Add-On block.

Preliminary flight path maps and magnetic maps were plotted and updated, to monitor coverage of the survey area.

6.2 BASE STATION

Two magnetic base stations were established in magnetically quiet areas.

The first, at the Skwentna Roadhouse, at Latitude: 61.971654; and Longitude: -151.194472 (see Figure 2.1), which was used for the Sustina (A1) block diurnal corrections.

The second base station was established at Rainy Pass Lodge, at Latitude: 62.091310; and Longitude: -152.736689 (see Figure 2.1), and was used for the Add-On block diurnal corrections.

Skwentna Roadhouse Base Station setup

Rainy Pass Lodge Base Station setup.

The base station readings were monitored to ensure that the diurnal variation were within the peak-to-peak envelope of 5 nT from a long chord distance equivalent to a period of five minutes.

6.3 AIRBORNE MAGNETOMETERS

FOM tests of the performance of the CS-3 and fluxgate magnetometers were performed in order to monitor the ability of the system to remove the effects of aircraft motion on the magnetic measurement.

The FOM maneuvers consisted of a series of calibration lines flown at high altitude (10,000+ ft above sea level) to gain information in each of the required line directions. During this procedure, pitch, roll and yaw maneuvers were performed on the aircraft.

The following ranges were used:

Pitch: 15^o
Roll: 15^o
Yaw: 15^o

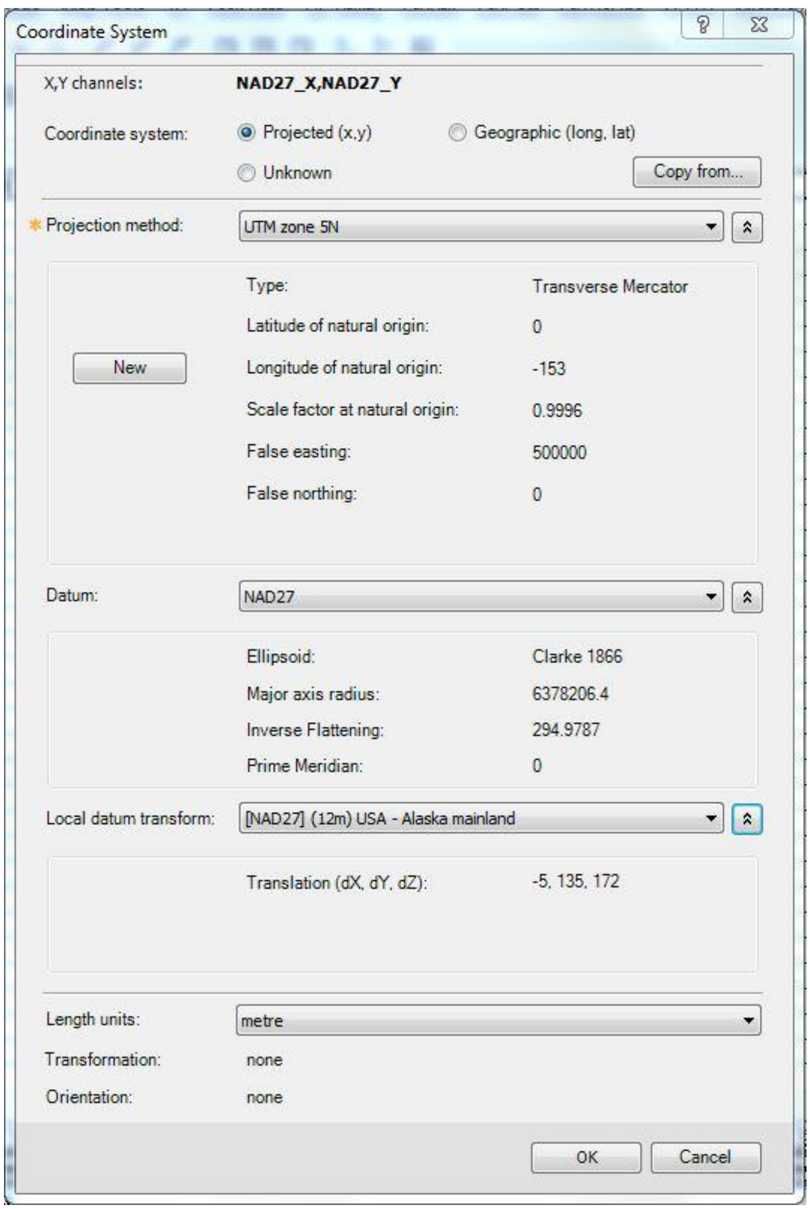
See Appendix A for the FOM results as flown on October 13th and November 1st, 2012, which were used to compensate the magnetic data.

6.4 DATA COMPILATION

Data recorded by the airborne and base station systems was transferred to the field compilation system. As each flight was completed, the following compilation operations were carried out:

6.4.1 FLIGHT PATH CORRECTIONS

The navigational correction process yields a flight path expressed in WGS84, World and transformed to correspond to NAD27, UTM Zone 5N, USA-Alaska mainland:



6.4.2 MAGNETIC CORRECTIONS

6.4.2.1 FILTERING AND COMPENSATION

The raw magnetic data (MAG_RAW) along with the fluxgate magnetometer data were filtered with a 31 cosine anti-aliasing algorithm and re-sampled at 10 Hz.

The filtered and re-sampled data were stored in the MAG_FILT channel.

Then the MAG_FILT data were compensated for permanent, induced, and eddy current magnetic noise generated by the aircraft using data from the fluxgate magnetometer (see Appendix A).

The compensated magnetic data were then stored in the MAG_COMP channel.

6.4.2.2 DIURNAL CORRECTIONS

The compensated magnetic data were adjusted to account for diurnal variations. The magnetic variations recorded at the base station recognized to be caused by man-made sources (such as equipment, vehicles passing by the sensor) were removed and gaps interpolated.

The base station diurnal data were recorded at 50Hz and filtered with a 155-point low pass filter, which is equivalent to a 3.1-point low pass filter on a 1 Hz scale (1 Hz scale is an industry-wide norm). The diurnal variations were calculated by subtracting the base stations project average magnetic field value (55,175.11nT for the Sustina (A1) block, and 55,688.38nT for the Add-On block) from the measured base station record during each flight. The filtered diurnal variation data were then subtracted directly from the aeromagnetic measurements to provide a first order diurnal correction.

Diurnal Corrected Data = Compensated Magnetic Data – Diurnal Variations

The resulting base station corrected data were stored in the MAG_DIURNAL_CORR channel.

6.4.2.3 HEADING CORRECTIONS

Optically pumped magnetic sensors have an inherent heading error, typically 1 to 2 nT peak-to-peak, as the sensor is rotated through 360 degrees. On flight line directions of the opposite heading, the affect is reasonably predictable.

A heading test flight was flown at magnetically quite area at 10,000+ ft above sea level altitude on October 13th, 2012 with the following results:

Table 6.1 Heading test flight results

Direction (deg.)	Mean on line (nT)	Mean in direction (nT)	Mean on heading (nT)	Error (nT)
45	55566.93	55566.08	55571.94	5.86
45	55565.23			
225	55578.92	55577.81		-5.86
225	55576.69			
135	55567.20	55568.16	55566.68	-1.48
135	55569.12			
315	55562.79	55565.20		1.48
315	55567.61			

The following heading corrections were applied to the data set:

```
/ Geosoft Heading Correction Table
/=   Direction:real:i
/=   Correction:real
/     Direction   Correction
    45        5.86
    135       -1.48
    225       -5.86
    315       1.48
    360       -3.67
```

The heading corrected magnetic data were stored in MAG_HEADING_CORR channel.

6.4.2.4 LAG CORRECTIONS

There are two potential types of Lag offsets when collecting airborne data: time lag and distance lag.

NSG insures that there is no time lag in the data acquisition system by recording unique markers 10/second based on the GPS time stamp (associated with the exact change, to within 20milsec accuracy, in GPS positioning). This information is used to realign (if necessary) the individual magnetic data records.

The distance lag is determined by dividing the fix distance from the GPS antenna to the sensor head by the averaged sample rate distance.

5.4m / 7.5m = 0.72 records

A lag correction of +1 record was applied to the MAG_HEADING_CORR channel and stored in the MAG_LAG_CORR channel.

6.4.2.5 LEVELING CORRECTIONS

After the data were corrected for lag, a survey traverse/control line intercepts matrix (i.e., Simple Leveling), was created for determining differences in magnetic field at the intersection points.

First the control lines were statistically adjusted (e.g., best fit) for the traverse line intersections. After, a new intersection table, using statistically leveled control lines, was calculated with the subsequent intersection points being used for the leveling of the traverse lines. Rugged terrain of the survey block (Add-On block especially) resulted in some line-to-line difference in altitude. Relatively strong magnetic anomalies made magnetic signal at some traverse/control line intersection points quite different. As a result, some of those intersection points needed to be manually adjusted in order to reduce line-to-line differences in the magnetic signal.

The resulting Simple Leveled traverse lines were then used for the final control line leveling, by calculating a new intersection table, and adjusting the control lines to the traverse line intersection points.

The resulting simple leveled magnetic data were stored in MAG_SMPL_LVL channel.

6.4.2.6 IGRF CORRECTIONS

The total field strength of the International Geomagnetic Reference Field (IGRF, 2010 model) was calculated for every data point, based on the spot values of fixed Date (October 15th, 2012), Latitude, Longitude, and fixed altitude of 300m. This IGRF was removed from the measured survey data on a point-by-point basis from the lag corrected channel.

The IGRF field variations were calculated by subtracting the region's average IGRF value (56,001.22 nT) from the calculated IGRF field at each record position. The IGRF variation data were then subtracted directly from the aeromagnetic lag corrected data.

IGRF Corrected Data = Lag Corrected Magnetic Data – IGRF variations

The IGRF corrections were applied to the MAG_SMPL_LVL channel and stored in the TMI_FINAL channel.

6.4.3 VERTICAL DERIVATIVE

First Order Vertical Derivative (VDV) data were calculated using 2D FFT2 algorithm based on the final microlevelled TMI grid. The resulting FFT2 VDV grid was sampled back to the database.

The following key microlevelling parameters were used on the final TMI grid before the calculation of the FFT2 VDV data:

Table 6.2 Magnetic data microlevelling parameters

Line Spacing (m)	Line Direction (deg.)	Grid Cell Size (m)	Decorrugation Cutoff (m)	Amplitude Limit (nT)	Amplitude Limit Mode	Naudy Filter Limit
800	135	160	3200	8.197	clip	0

Note: see Appendix D for the description of the microlevelling GX.

The VDV data were stored in the VDV channel.

6.4.4 DIGITAL TERAIN MODEL (DTM)

Due to very rugged terrain over the Add-On block and a few spots over the Sustina block, the radar altimeter data were out of its range (>~2,500ft above ground) briefly on some lines, and for that reason no Digital Terrain Model was calculated for this survey.

6.4.5 GRIDDING

The final TMI and VDV grids were produced from the TMI_FINAL and VDV channels respectively.

The data were gridded using a Minimum Curvature gridding method with a grid cell size of 220 meters and a tolerance of 0.01.

6.4.6 MAGNETIC DATA SYNCHRONIZATION CORRECTIONS

As per client’s request, the final TMI data were synchronized with previously flown survey south of the Sustina (A1) block.

The differences between the two surveys were found by studying the areas of overlap of the magnetic grids between those projects. Such analysis was performed by Intrepid Gridmerge v4.0 Release Built 59 software package (courtesy of Christopher (Kit) Campbell at Intrepid Geophysics Ltd.). Table 6.3 shows the calculated offsets which were applied to the data.

Table 6.3 Magnetic data synchronization offsets

Survey Name	Applied Offset (nT)
Current Survey	-55,679.78
Past Survey	0

It should be noted, the two surveys were flown at different nominal altitudes: the current survey was flown at 300m nominal, and the past survey was flown at 200m nominal. For that reason the synchronization of data should be treated with caution.

The synchronization offset was applied to TMI_FINAL channel and the resulting data were stored in TMI_sync channel.

7. MAP PRODUCTS AND DIGITAL DATA DELIVERABLES

The following is the list of items delivered to **U.S. Geological Survey**

1) Hard Copy Logistics Report (x2):

2) Digital Copy Grids in Geosoft GRD format (DVD) (x2):

- Grid of Total Magnetic Intensity (nT)
- Grid of 1st order Vertical Derivative (nT/m)

3) Digital Copy (DVD) Database in Geosoft GDB and ASCII formats (x2) (see Appendix B for detail info)

4) Digital Copy (DVD) Logistics Report (MSWord) (x2)

5) Digital Copy of Weekly and Line Progress Report (MSExcel) (x2)

6) Flight videos (34 DVDs)

- **FLT003.A, FLT003.B**
- **FLT005.A, FLT005.B, FLT005.C**
- **FLT006.A, FLT006.B**
- **FLT007.A, FLT007.B, FLT007.C**
- **FLT008.A, FLT008.B, FLT008.C**
- **FLT009.A, FLT009.B, FLT009.C**
- **FLT010.A, FLT010.B**
- **FLT011.A, FLT011.B**
- **FLT012.A, FLT012.B, FLT012.C**
- **FLT013.A, FLT013.B**
- **FLT014.A, FLT014.B, FLT014.C**
- **FLT015**
- **FLT016.A, FLT016.B**
- **FLT019**
- **FLT020**
- **FLT021**

7) Raw data files (external hard drive) (x1)

8. SUMMARY

This report describes the logistics of the survey, equipment used, field procedures, data acquisition and presentation of results.

The various maps included with this report display the magnetic and radiometric properties of the survey area. It is recommended that the survey results be reviewed in detail, in conjunction with all available geophysical, geological and geochemical information.

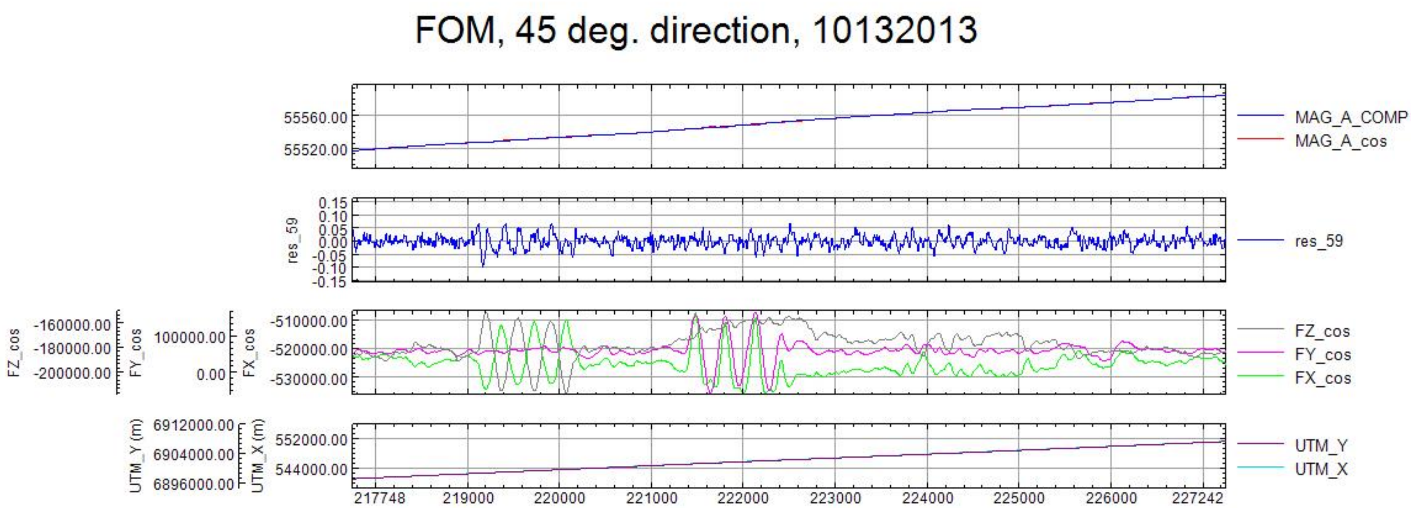
Further processing of the data may enhance subtle features that can be of importance for exploration purposes.

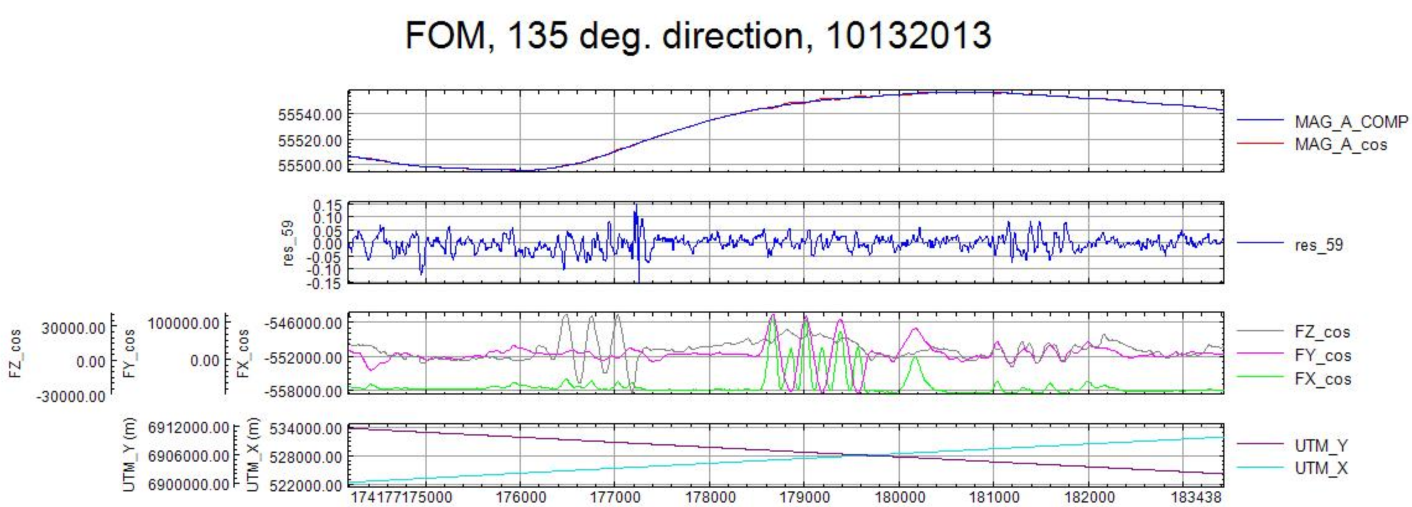
Respectfully submitted,

Andrei Yakovenko
New-Sense Geophysics Ltd.
Date: January 16th, 2013

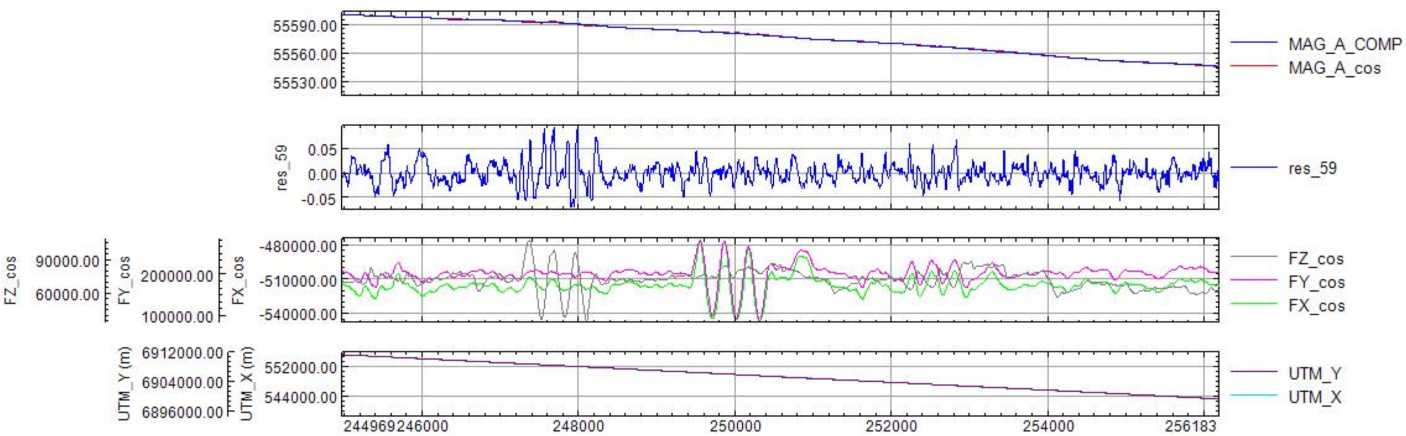
APPENDIX A: FOM RESULTS

13-Oct-12					
line	**direction**	**pitch**	**roll**	**yaw**	**total**
10	**315**	0.15	0.06	0.20	0.41
20	**135**	0.15	0.10	0.14	0.39
30	**45**	0.10	0.10	0.10	0.30
40	**225**	0.15	0.08	0.10	0.33
	total	0.55	0.34	0.54	**1.43**

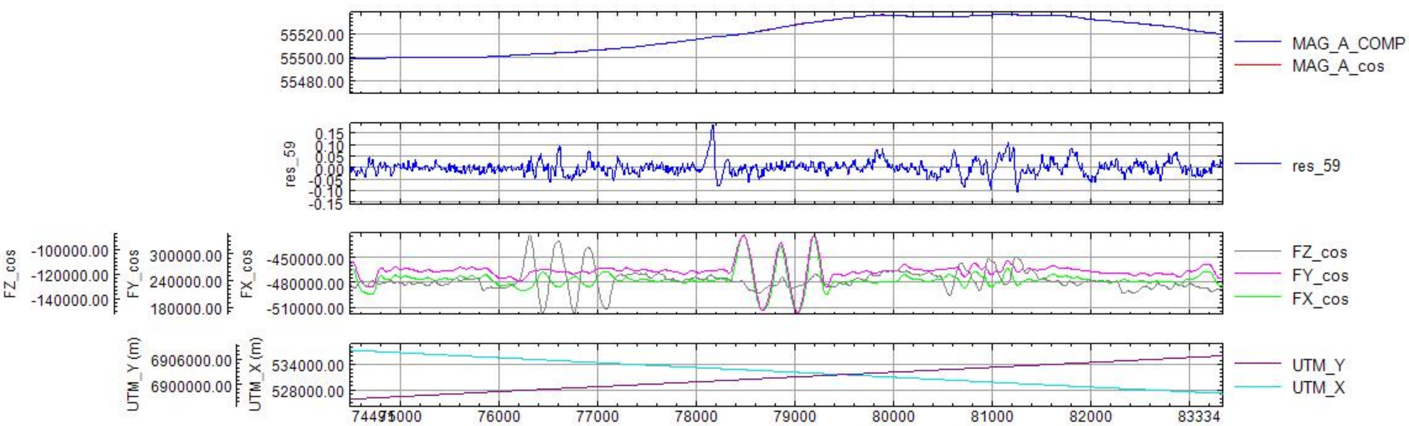




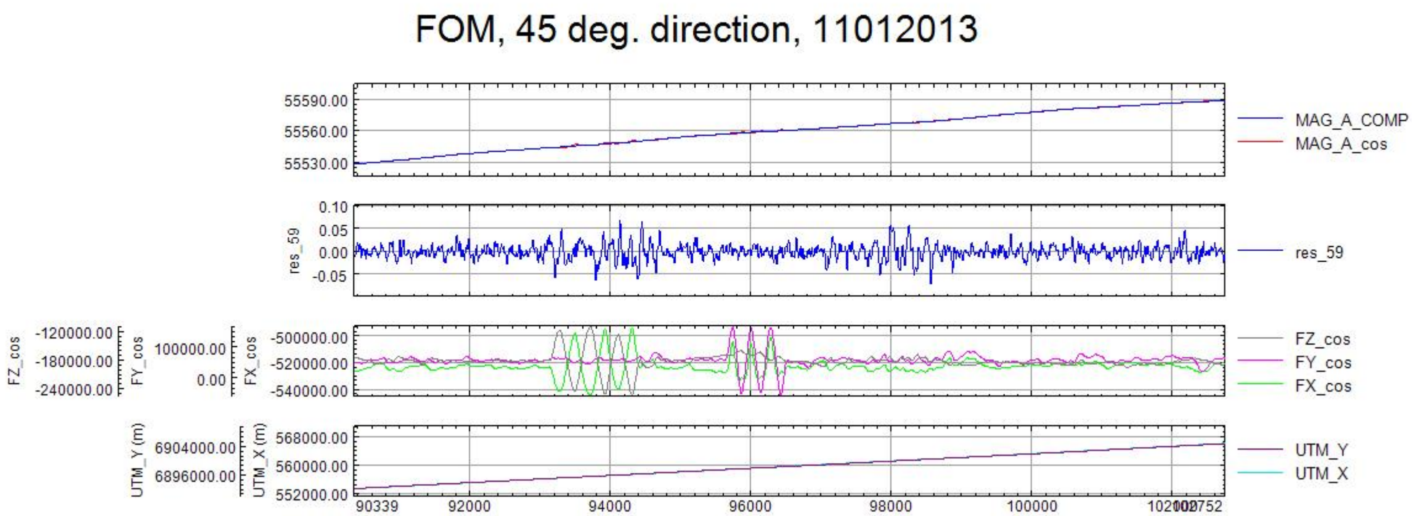
FOM, 225 deg. direction, 10132013

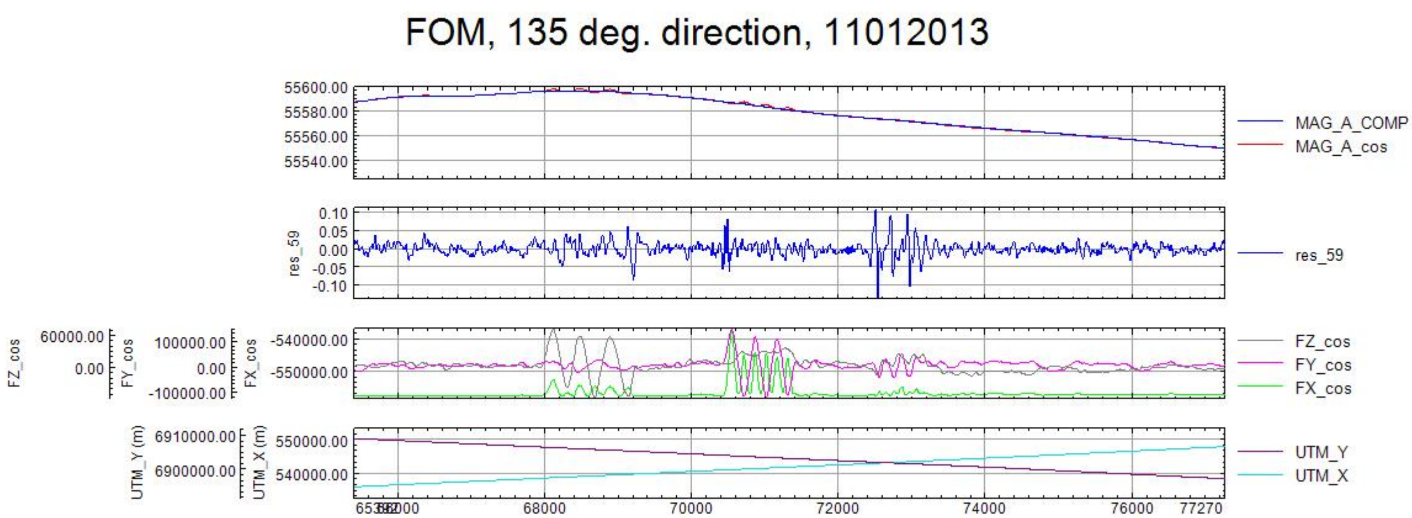


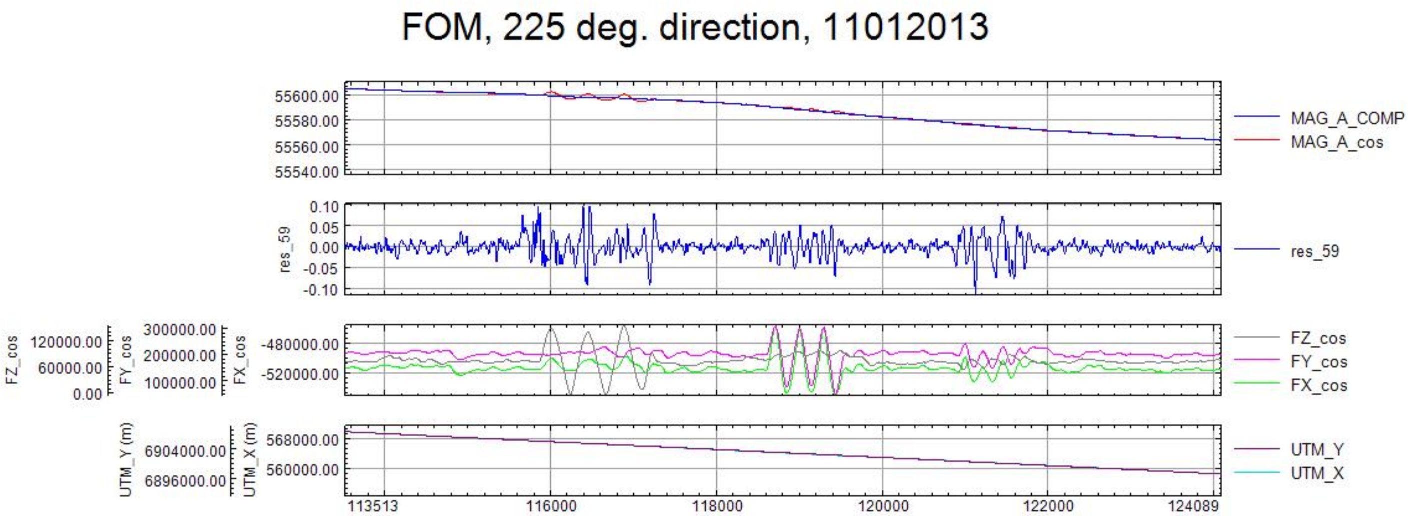
FOM, 315 deg. direction, 10132013

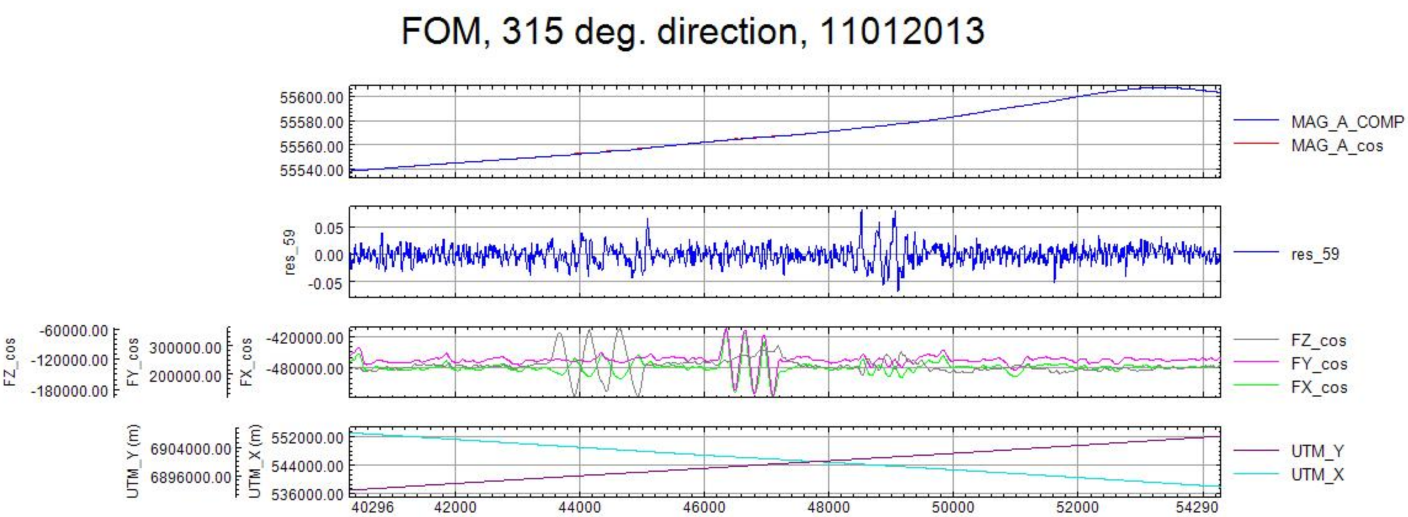


01-Nov-12					
line	**direction**	**pitch**	**roll**	**yaw**	**total**
10	**45**	0.13	0.03	0.10	0.25
20	**225**	0.18	0.12	0.15	0.45
30	**315**	0.07	0.05	0.15	0.27
40	**135**	0.15	0.13	0.25	0.53
	total	0.53	0.32	0.65	**1.49**






FOM, 225 deg. direction, 11012013
55600.00
55580.00
55560.00
55540.00
MAG_A_COMP
MAG_A_cos
res_59
0.10
0.05
0.00
-0.05
-0.10
res_59
FZ_cos
120000.00
60000.00
0.00
FY_cos
300000.00
200000.00
100000.00
FX_cos
-480000.00
-520000.00
FZ_cos
FY_cos
FX_cos
UTM_Y (m)
6904000.00
6896000.00
UTM_X (m)
568000.00
560000.00
UTM_Y
UTM_X
113513
116000
118000
120000
122000
124089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55580.00
55560.00
55540.00
MAG_A_COMP
MAG_A_cos
res_59
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0.00
-0.05
res_59
FZ_cos
-60000.00
-120000.00
-180000.00
FY_cos
300000.00
200000.00
FX_cos
-420000.00
-480000.00
FZ_cos
FY_cos
FX_cos
UTM_Y (m)
6904000.00
6896000.00
UTM_X (m)
552000.00
544000.00
536000.00
UTM_Y
UTM_X
40296
42000
44000
46000
48000
50000
52000
54290

APPENDIX B: DATABASE DESCRIPTIONS

Magnetic Database

Database Names: Sustina_Airborne_2012.gdb; Sustina_Airborne_2012.xyz
Format: Geosoft .gdb; ASCII .xyz
Number of Channels: 32

Note: If the database is opened in Oasis montaj, please load included "*Magnetic Geosoft channel display.dbview*" file to insure that ALL the channels are displayed in the same order as listed below (Database menu -> Get Saved View).

Channel Name	Units	Description
LINE	number	Line number
LINE_DIRECTION	deg.	Line direction
FLIGHT	number	Flight number
DATE	Julian date	Date flown (YYYYDDD)
FIDUCIAL	number	Fiducial count (flight specific)
TIME	hh:mm:ss.ss	Operating system time
SYSTEM_CLOCK	milsec	KANA8 (A/D converter) counter
NAD27_X	meters	NAD27 Easting, Z5N, Alaska mainland
NAD27_Y	meters	NAD27 Northing, Z5N, Alaska mainland
WGS84_X	meters	WGS84 Easting, Z5N, World
WGS84_Y	meters	WGS84 Northing, Z5N, World
LATITUDE_NAD27	degrees	GPS latitude, NAD27, Alaska mainland
LONGITUDE_NAD27	degrees	GPS longitude, NAD27, Alaska mainland
GPS_HEIGHT_WGS84	meters	GPS height (orthometric) above MSL, WGS 84, World
UTC_DAYSEC	decimal seconds	UTC daily second counter (0-86399)
FLUX_X	volts	Fluxgate x-axis
FLUX_Y	volts	Fluxgate y-axis
FLUX_Z	volts	Fluxgate z-axis
RAD_ALT_m	meters	Radar altimeter, height above ground
MAG_RAW	nT	Raw magnetometer data
MAG_FILT	nT	Filtered raw magnetometer data
MAG_COMP	nT	Compensated magnetometer data
DIURNAL	nT	Base station (diurnal) magnetometer data
MAG_DIURNAL_CORR	nT	Diurnal corrected magnetometer data
MAG_HEADING_CORR	nT	Heading corrected magnetometer data
MAG_LAG_CORR	nT	Lag corrected magnetometer data
MAG_SMPL_LVL	nT	Conventionally (simple) leveled magnetometer data
IGRF	nT	Calculated IGRF, 2010 model
TMI_FINAL	nT	Final TMI (IGRF corrected MAG_SMPL_LVL data)
VDV	nT/m	1st Order Vertical Derivative
TMI_sync	nT	Synced final TMI to previously flown survey

APPENDIX C: IMAGES OF FINAL MAPS

Image of final TMI map

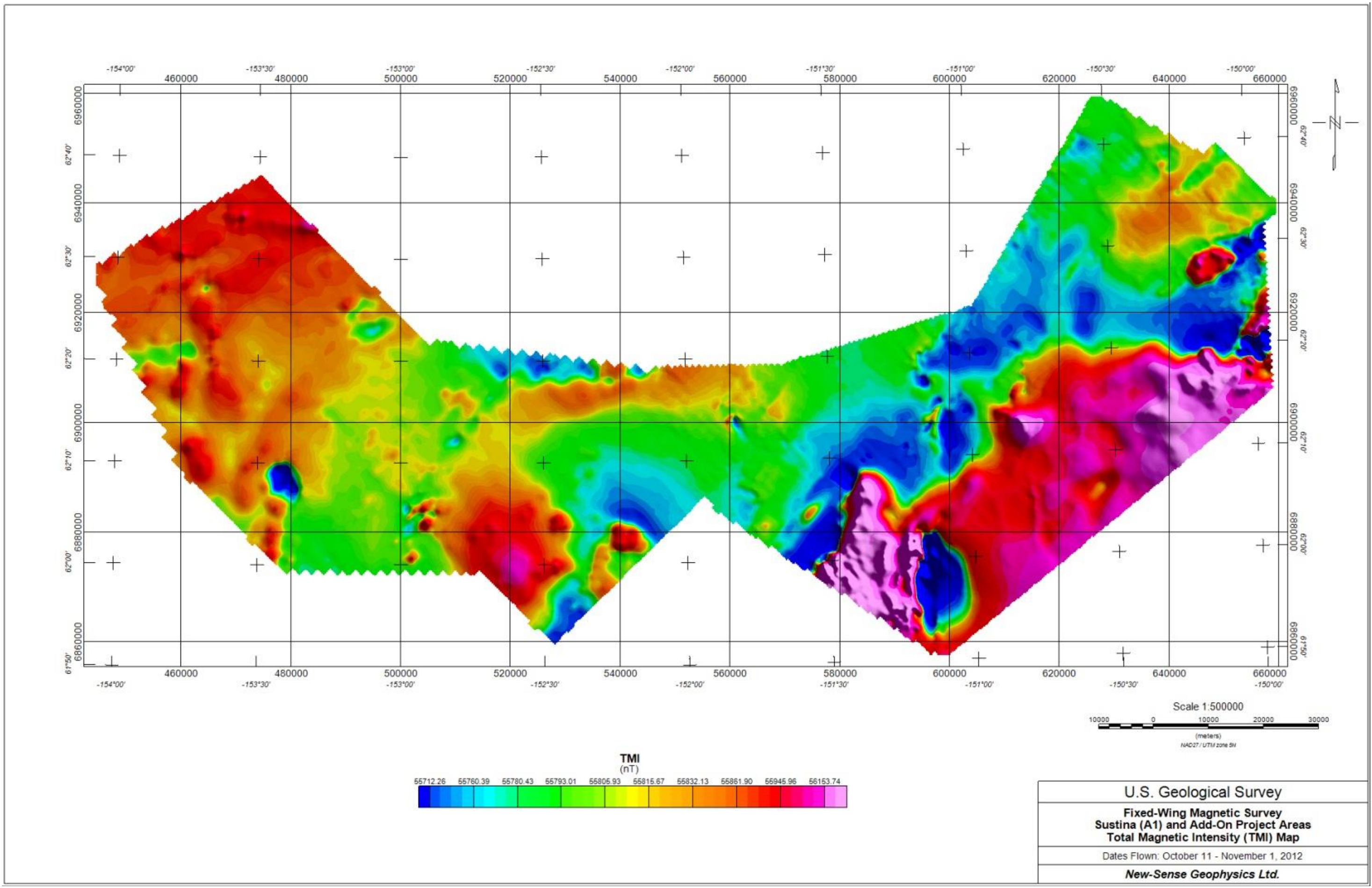
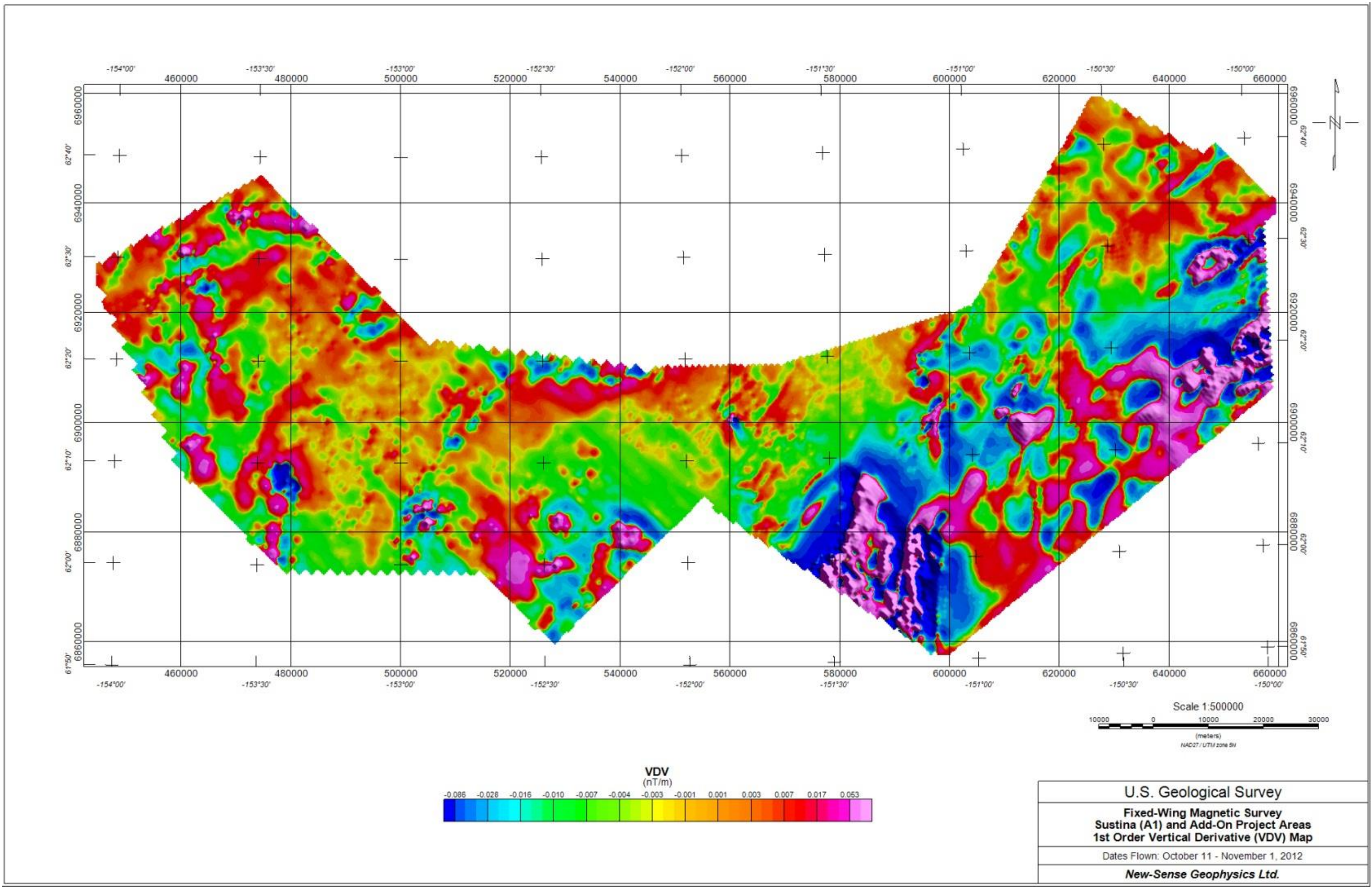


Image of final VDV map



APPENDIX D: MICROLEVVELING DESCRIPTION

As per PGW Microlevelling GX help file available through Geosoft Oasis montaj 7.2

```
DECORR.GX                Version 3.0
                         Paterson, Grant & Watson Limited
                         March 2003

PARAMETERS: (miclev group parameters are used, so that values set will be
             passed to MICLEV.GX)

   miclev.Xchan = x channel (default "x")
         .Ychan = y channel (default "y")
         .Ochan = original data channel (no default)
         .Nchan = decorrugation noise channel (default "dcor_noise")
         .Space = flight line spacing
         .Dir   = flight line direction in degrees azimuth (clockwise
                  from North)
         .Cell  = cell size to use for gridding (default = line spacing/5)
         .Wlen  = decorrugation high-pass wavelength (default = 4 * line
                  spacing)
         .Ogrid = original output grid, new or existing
         .Nnoise= decorrugation noise grid
         .XY    = Xmin,Ymin,Xmax,Ymax            (optional)
         .LOGOPT= Log option                     (optional)
         .LOGMIN= Log minimum                    (optional)
         .DSF   = Low-pass desampling factor     (optional)
         .BKD   = Blanking distance              (optional)
         .TOL   = Tolerance                      (optional)
         .PASTOL= % pass tolerance               (optional)
         .ITRMAX= Max. iterations                (optional)
         .ICGR  = Starting coarse grid           (optional)
         .SRD   = Starting search radius         (optional)
         .TENS  = Internal tension (0-1)         (optional)
         .EDGCLP= Cells to extend beyond data    (optional)
```

DESCRIPTION:

decorr.gx and miclev.gx implement a procedure called micro-levelling which removes any low-amplitude component of flight line noise still remaining in airborne survey data after tie line levelling. Micro-levelling calculates a correction channel and adds it to the profile database. This correction is subtracted from the original data to give a set of levelled profiles, from which a final levelled grid may then be generated. Microlevelling has the advantage over standard methods of decorrugation that it better distinguishes flight line noise from geological signal, and thus can remove the noise without causing a loss in resolution of the data.

To microlevel data, first run decorr.gx, then miclev.gx. decorr.gx offers two options for the grid of the channel to be microlevelled. If a grid prepared from this channel already exists, it may be specified, and when prompted to overwrite, the user should answer no. If the user wishes to prepare a new grid of the channel to be microlevelled, the minimum curvature gridding algorithm (rangrid.gx) is applied. The advanced button provides access to the standard minimum curvature gridding parameters. Once the gridding is completed, decorr.gx applies a directional high-pass filter (see end note) perpendicular to the flight line direction, in order to produce a decorrugation noise grid. (The default grid cell size is 1/5 of the line spacing. The user may specify a different cell size if desired. A smaller cell size will give a more accurate result, but a larger cell size will make the gx run faster and use less disk space.) The noise grid is then extracted as a new channel in the database (default name is "dcor_noise"). This channel contains the line level drift component of the data, but it also contains some residual high-frequency components of the geological signal. miclev.gx applies amplitude limiting and low-pass filtering to the noise channel in order to remove this residual geological signal and leave only the component of line level drift, which is then subtracted from the original data to produce a levelled output channel named "miclev".

decorr.gx calculates default amplitude limit and filter length values for use in miclev.gx, but the skilled user may be able to set better values for these parameters based on an inspection of the noise grid. (The micro-levelling process is broken up into two separate GXes in order to allow the user to do this.) Flight line noise should appear in the decorrugation noise grid as long stripes in the flight-line direction, wheras geological anomalies should appear as small spots and cross-cutting lineaments, generally with a higher amplitude than the flight line noise, but with a shorter wavelength in the flight-line direction. The user can estimate the maximum amplitude of the flight line noise, and set the noise amplitude limit value accordingly. Similarly the user can estimate the minimum wavelength of the level drift along the flight lines, and set the low-pass Naudy filter width to half this wavelength. The defaults are to set the amplitude limit equal to the standard deviation of the noise grid, and to set the filter width equal to five times the flight line spacing.

There is an option of using either of two kinds of amplitude limiting. In "clip" mode any value outside the limit is set equal to the limit value. In "zero" mode any value outside the limit is set equal to zero. The clip mode makes more sense intuitively, but it has been found in practise that the zero mode may reject geologic signal better, depending on the particular data set. As a rule the zero mode works better on datasets in which the noise grid contains a lot of high-amplitude geological signals (e.g. shallow basement areas). For datasets in which the noise grid contains mainly flight line noise (e.g. sedimentary basins), the clip mode works better.

Microlevelling applies a level correction to the traverse lines only. If it is desired to grid the tie lines together with the micro-levelled traverse lines, then it may be necessary to also apply a level correction to the tie lines so that their values agree with the micro-levelled traverse lines at the intersections. This may be done as follows:

1) Copy the tie line values to the microlevelled channel.

2) Use intersct.gx to find cross-difference values for the microlevelled data.

3) Use xlevel.gx to load these cross-difference values to the tie lines.

4) Apply fulllev.gx to the tie lines. The output will be a set of tie lines that matches the microlevelled traverse lines at all inter-

sections.

5) Copy the microlevelled traverse line values into the same channel as the corrected tie line values.

Decorrugation Filter:

The decorrugation noise filter is a sixth-order high-pass Butterworth filter with a default cutoff wavelength of four times the flight line spacing, combined with a directional filter. The directional filter coefficient as a function of angle is F=(sin(a))^2, where a is the angle between the direction of propagation of a wave and the flight line direction,i.e. F=0 for a wave travelling along the flight lines, and F=1 for a wave travelling perpendicular to them. (Note this is the exact opposite of what is usually called a decorrugation filter, since the intention here is to pass the noise only, rather than reject it.)

The default cutoff wavelength (4 * line spacing) gives good results if the data is already fairly well levelled to start with. In cases where many lines are badly mis-levelled, it may be necessary to set a longer cutoff wavelength, at the risk of removing more geological signal.